BIO-SOLARIZATION FOR STRAWBERRY PRODUCTION IN SPAIN: 2009 RESULTS.

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The Spain's Methyl Bromide Alternatives Project (INIA) has allowed 12 years of work for strawberry in Huelva (Spain). In 2008/09 a field trial with non-chemical alternatives to MB has been conducted in the Experimental Farm "El Cebollar" (IFAPA), located in Moguer (Huelva). Complete randomized block design with 4 replications (20 m^2/rep. & 150 plants/rep.) and 8 treatments was used. Strawberry cv. 'Camarosa' was cultivated following conventional cultivation practices under high-tunnels. These non-chemical treatments belong to a series of bio-solarization techniques, using the annual application of biofumigation with chicken manure and soil solarization during July and August, developed by our working group since 1999 (Medina et al., 2004, 2008a, 2008b) and brassica pellets (Lazzeri et al., 2009). Fumigant treatments applied between July, 15 and August, 20, 2008, were:

.-A: untreated control (UC);
.-B: Biosolarization with fresh chicken manure (30,000 kg/ha) (BIOSOL-F-30);
.-C: Biosolarization with dry (fermented) chicken manure (30,000 kg/ha) (BIOSOL-D-30);
.-D: Biofumigation with fresh chicken manure (30,000 kg/ha), without soil solarization (BIOFUM-F-30);
.-E: Biosolarization with fresh chicken manure (15,000 kg/ha) (BIOSOL-F-15);
.-F: Biosolarization with fresh chicken manure (7,500 kg/ha) (BIOSOL-F-7.5);
.-G: Biosolarization with brassica pellets (BioFence™) (2,000 kg/ha) (BIOSOL-B-2);
.-H: Biofumigation with brassica pellets (BioFence™) (2,000 kg/ha), without soil solarization (BIOFUM-B-2).

Treatment B (BIOSOL-F-30) is the overall standard in the Experimental Farm since 1999 (Medina et al., 2008a), with 7 main steps as material and methods: 1: Application & incorporation (mid-July) of the biofumigant chicken manure to the soil; 2: Short sprinkler irrigation, just before covering the soil with transparent film (mid-July); 3: Application of LDPE transparent film sheets (50 microns) on strips 3.30 m wide and 0.30-0.35 m of separation among strips (mid-July), for soil solarization; 4: Biosolarization effect into the soil during 5 weeks (from mid-July up to end-August); 5: LDPE film removal (end-August); 6: Formation and

mulching of beds (mid to end-September); 7: Plantings (from early to mid-October).

Application/incorporation of fumigant chicken with rotovator was conducted on July 15, 2008. Application of LDPE transparent film with soil solarization implement was conducted on July 16, 2008; and plastic removal on August 20, 2008. Planting was done on October 15, 2008.

Soil samples from each replication were evaluated for fungal presence before (early-July, 2008) and after (October, 2008) treatments. Most part of treatments reduced significantly initial fungal population: before treatments ranged between 10^5 and 10^6 CFU per gram of soil, and between 10^5 and 10^6 after treatments. However, treatments D (BIOFUM-F-30) and H (BIOFUM-B-2) (biofumigation without soil solarization) did not reduce significantly microbiota. Results will be presented and discussed.

Plant vigour: 10 randomly selected plants from each bed were observed throughout the complete growing season. Plant diameter was determined by taking two measurements of the above ground foliage from each plant. Results will be presented and discussed.

Samples from 10 plants per replication used for plant vigour (diameter) evaluation were examined at the end of the growing season (May 6-7, 2009), five plants for soil-borne fungi and five plants for nematodes presence. Additionally, 24 samples of symptomatic plants that indicated different aerial symptoms (in particular collapsed, wilt, or very small plants) were taken.

Very low presence of nematodes *Pratylenchus penetrans* and *Meloidogyne hapla* was detected at the end of the cultivation period (Table 1). Results will be presented and discussed. In samples of 5 plants/replication, high isolation frequencies of *Cylindrocarpon* spp. and *Rhizoctonia* spp. in roots, and *Pythium* and *Fusarium* spp. in crowns and roots were detected. For additional symptomatic plants samples, high isolation frequencies of *Fusarium* spp. and *Cylindrocarpon* spp. were detected; and, in particular *Rhizoctonia* spp. in treatment D (BIOF-F-30). Results will be presented and discussed.

Weed control assessment was done on August 20, 2008 by means of observations of weed emergence after soil solarization; and on December 17, 2008 (this control was focused on the weeds growing on the bed tops mulched with black LDPE film). In solarized treatments, little emergence of weed was observed after plastic removal (mainly common purslane, *Portulaca oleracea*, which is very frequent in summer); only in treatments C and G small amounts of purslane were removed. However in untreated control (A) and in non-solarized treatments (D and H) weed density was very high. In the control of December 17, 2008 no significant differences among treatments were observed in weed biomass, number of weed and time needed to removed the weeds per replication.

Agronomical traits such as plant survival, early and total yield and fruit size were recorded (Table 2). Results and current status of MB replacement for strawberry cultivation in the area of Huelva (in particular serious problems for chemical fumigant applications in Mediterranean European countries due to the implementation of the Directive 91/414/EEC) will be presented and discussed.

References

Lazzeri, L., Malaguti, L., D'Avino, L. , Lazzari, A., Moncada, A. and Palermo, M.L. 2009. Potencialità applicative dei nouvi materiali solidi e liquidi per la biofumigazione nella coltivazzione della fragola. VII Convengo Nazionale, la fragola presente e futuro. Marsala (Italia), 25-27 marzo 2009. Libro dei Riassunti.

Medina, J.J., Miranda, L., Romero, F., De Los Santos, B., Montes, F., Vega, J.M., Páez, J.I., Bascón, J., Soria, C. and López-Aranda, J.M. 2004. The use of biofumigation with new types of solarisation film for strawberry production in Spain. Proceedings of Fifth International Conference on Alternatives to Methyl Bromide, Tom Batchelor and Flávia Alfarroba, eds., Lisbon, (Portugal), 27-30/9/2004: 61-65.

Medina, J.J., Miranda, L., Soria, C., Palencia, P. and López-Aranda, J.M. 2008a. Non-chemical Alternatives to Methyl Bromide for Strawberry: Biosolarization as Case-study in Huelva (Spain). VI International Strawberry Symposium ISHS 2008. Islantilla (Huelva). Spain. 03/03/2008. Book of Abstracts. ID: 910.pp.237.

Medina, J.J., Miranda, L., Soria, C., Domínguez, P., Pérez-Jiménez, R.M.; Zea, T., Talavera, M., Romero, F., De Los Santos, B., and López-Aranda, J.M. 2008b. Alternativas biológicas al Bromuro de metilo en la fresa de Huelva (España), resultados de dos años de actividades. VI Seminario Científico Internacional de Sanidad Vegetal. II Conferencia Internacional sobre Alternativas al Bromuro de metilo. Palacio de Convenciones: La Habana (Cuba). 25/09/2008. CD Memorias/Proceedings. Programa Científico: 49.

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Table 1. Nematode populations at the end of the growing season.

	Pratylenchus penetrans	*Meloidogyne hapla*		
Treatments	individuals/g of roots	Gall Index: Severity Index[1]	Nº eggs+ J_2/g of roots	females/g of roots
A: UC	88.98 b	0.50 b	125.71 c	0.70 a
B: BIOSOL-F-30	0.00 a	0.00 a	0.22 a	0.00 a
C: BIOSOL-D-30	1.84 a	0.10 b	17.04 ab	1.41 a
D: BIOFUM-F-30	24.68 b	0.10 b	17.31 ab	0.99 a
E: BIOSOL-F-15	1.56 a	0.00 b	0.27 a	0.00 a
F: BIOSOL-F-7.5	0.18 a	0.05 b	6.26 a	0.09 a
G: BIOSOL-B-2	1.45 a	0.05 b	14.46 ab	1.11 a
H: BIOFUM-B-2	1.94 a	0.05 b	39.29 b	2.38 a

Values are means of three replicates. Means followed by the same letter in each column were not significantly different ($0.05 \leq P$) by the LSD test. Transformation log (1+x).
[1]Severity Index Scale: 0 (No symptoms) to 4 (all roots attacked).

Table 2. Total commercial yield in grams/plant and fruit weight in grams.

Treatments	Total yield[1]	Relative yield[2]	g/fruit	Relative weight[1]
A: UC	616 c	100.0 c	25.3 c	100.0 c
B: BIOSOL-F-30	862 a	139.9 a	28.3 a	112.0 a
C: BIOSOL-D-30	680 bc	110.4 bc	25.6 c	101.1 c
D: BIOFUM-F-30	686 bc	111.4 bc	25.6 c	101.2 c
E: BIOSOL-F-15	832 a	135.1 a	26.6 abc	105.2 abc
F: BIOSOL-F-7.5	696 bc	113.0 bc	27.0 abc	106.5 abc
G: BIOSOL-B-2	751 ab	121.9 ab	27.4 ab	108.1 ab
H: BIOFUM-B-2	660 bc	107.1 bc	26.2 bc	103.5 bc

[1]Cumulated up to May 27th, 2009; [2]Relative yield in relation to UC untreated treatment = 100%; $P \leq 0.05$. Values are means of four replicates. Means followed by the same letter in each column were not significantly different ($0.5 \leq P$) by the LSD test.